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AMMONIUM NITRATE FUEL BLOCKS

by

Edward P. Cole

February 1960

Weapons Research Division
Directorate of Research
U. S. ARMY CHEMICAL WARFARE LABORATORIES
Army Chemical Center, Maryland

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AMMONIUM NITRATE FUEL BLOCKS

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Carl M Herget
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Acting Director of Research

DIGEST

The object of the work described in this report was to determine whether the physical variables inherent in the procedure for loading AN-M7 smoke-pot fuel blocks had any noticeable effect on the observed tendency of the blocks to swell during storage.

No relationship was found between consolidation pressure, ram dwell time, or the presence of a cellulose-nitrate disk seal, and the tendency of fuel blocks to swell. There was a correlation between slight swelling and (1) the addition of 2% water to the fuel mixtures prior to consolidation and (2) consolidation of the fuel mixture in one increment instead of two. It was also found that the starter mixture showed signs of swelling, that blocks having a concave top surface swelled, and that "fast" (MIL-STD-545) fuel mixtures showed considerably greater swelling than pure ammonium nitrate blocks. All the miniature fuel blocks used in the experiments swelled after storage.

No change in the physical variables inherent in the loading procedure of fuel blocks is capable of completely eliminating the tendency of ammonium nitrate fuel blocks to swell.

CONTENTS

GLOSSARY OF TERMS

Collodion	An 8% solution of cellulose nitrate in acetone
Consolidation pressure	The pressure in lb/sq in. at which the fuel mixtures are consolidated into fuel blocks
Dwell time	The length of time during which the consolidation pressure is applied to the fuel mixtures
"Fast" mixture	A fast-burning fuel mixture (MIL-STD-546)
"Slow" mixture	A slow-burning fuel mixture (MIL-STD-545)

AMMONIUM NITRATE FUEL BLOCKS

I. INTRODUCTION.

The object of the work described in this report was to determine whether the physical variables inherent in the procedure for loading AN-M7 smoke-pot fuel blocks had any noticeable effect on the observed tendency of the blocks to swell during storage.

Data obtained during the period 1949 to 1953 by the Chemical Corps Materiel Command in conducting depot surveillance of the AN-M7 floating, oil-smoke pot indicated a relatively high degree of malfunctioning caused by the swelling of fuel blocks. This swelling was frequently of sufficient magnitude to completely block the venturi, preventing ignition of the fuel block. Fuel blocks of recent manufacture also exhibited this deficiency.

The problem was referred to the Chemical Corps Engineering Command for consideration. After a comprehensive study[1] it was concluded that: (a) the length of dwell time is apparently not related to the tendency of fuel blocks to swell; (b) thirty days of static surveillance under desert, tropical, and arctic conditions indicated that the tendency to swell was aggravated by heat; and (c) all fuel blocks manufactured with current formulas were likely to swell under the imposed storage conditions. The report also stated that the allotropism of the ammonium nitrate in the fuel mixtures was probably the principal cause of the swelling, and that new formulations were being studied with a view toward eliminating ammonium nitrate from the mixture.

A miniature fuel block containing 115 grams of ammonium nitrate was designed for investigating the swelling phenomenon because this size was consistent with the available experimental loading facilities for the AN-M6 training oil-smoke pot. Previous experience with miniature fuel blocks of this size had shown that they, too, swelled during storage in a manner similar to the larger AN-M7 fuel blocks.

The literature[2] reports that there are five crystalline modifications of ammonium nitrate between the temperatures of -18°C and 125°C.

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1. Howes. ENASR-PR No. 4. Evaluation of Experimental Modifications of the Pot, Smoke, Floating, Mark V, Model 2. pp. 4-8. March 1953.
2. National Research Council of America. International Critical Tables of Numerical Data. Vol. IV. McGraw-Hill Book Company. New York. p. 11. 1928.

At $32^{\circ}C$ and 1-atmosphere pressure, an allotropic change occurs in the crystalline structure of ammonium nitrate accompanied by a change in volume amounting to 20.26 ml/kg.

Each miniature fuel block contained approximately 115 grams of ammonium nitrate, and at 1-atmosphere pressure and a temperature of $32^{\circ}C$ the allotropic volume change should be 2.33 ml. The maximum volume of swelling noted in a typical miniature fuel-block test specimen was, however, roughly 4.07 ml which was greater than the volume attributable solely to allotropic change. Swelling in the test specimens, greater than can be explained by allotropic change alone, may arise from the fact that the fuel blocks are composed of small crystalline grains of ammonium nitrate (separated by particles of paraffin and charcoal) that swell individually. Since the miniature fuel block is confined in a metal container, the pressure can only be relieved by a buckling of the upper portion with the result that the upper surface becomes dome-shaped and often cracks.

Upon examination, the upper, buckled portions of the fuel blocks were found to be less consolidated than the lower portions, and in some cases an air space was found directly underneath the domed, crusty layer of fuel material. The total volume change caused by this upwarping and disconsolidation was greater than the sum of the allotropically caused volume changes of the individual ammonium nitrate grains. Since full-scale AN-M7 fuel blocks are confined circumferentially when in the smoke pot, it is possible that an allotropic swelling in the ammonium nitrate grains during storage could also be the cause for the observed upwarping of these blocks.

II. EXPERIMENTAL PROCEDURE, RESULTS, AND DISCUSSION.

The variables examined to determine their effect on the tendency of the smoke-pot fuel blocks to swell during periods of storage were: (a) consolidation pressure; (b) dwell time; and (c) percentage of moisture in the mixtures. Tests were also run to determine whether: (a) the presence of a starter mixture (MIL-STD-601) directly in the center of the fuel block had any effect upon overall swelling; (b) "fast" and "slow" mixtures and pure ammonium nitrate would swell similarly; (c) blocks pressed in one increment showed any difference in their tendency to swell from blocks pressed in two increments; (d) blocks sealed with a cellulose-nitrate disk would swell differently from unsealed blocks; and (e) blocks pressed with a convex ram (and therefore having a concave top surface) would swell any differently from blocks pressed with a flat ram.

A. Experimental Procedure.

Mixtures having identical chemical compositions, but different moisture content, were pressed into an open AN-M6 training smoke-pot bodies under varying consolidation pressures and dwell times. The test specimens were scaled down from 4 3/8 in. in height by 8 in. in diameter (dimensions of the AN-M7 fuel block) to 1 1/4 in. in height by 2 1/4 in. in diameter. In most of the tests conducted, the AN-M6 bodies containing fuel blocks were placed in fiberboard packing containers sealed with tape.

Except in a few cases, the specimen blocks were made up of 107 grams of "slow" fuel mixture (MIL-STD-545, appendix A) superimposed on 25.4 grams of "fast" fuel mixture (MIL-STD-546, appendix A). The mixtures were pressed in two separate increments in all blocks except in a few specified groups. The fuel-mixture compositions were:

"Fast" Mixture	"Slow" Mixture
88.7% Ammonium nitrate	86.5% Ammonium nitrate
10.3% Charcoal	9.0% Charcoal
1.0% Paraffin	4.5% Paraffin

The amount of swelling in the test fuel blocks was determined by scaling the distance from the top of the M6 body to the top of the fuel block before and after storage. The difference between the two measurements represented the amount of swelling during storage; the readings were accurate to within ±0.005 in. The consolidation pressures were read to within ±100 psi, and the dwell times to within ± 1 second.

B. Results and Discussion.

1. Consolidation Pressure.

Table 1 presents data on fuel mixtures having different moisture content and varying consolidation pressures and dwell times. All other controllable factors were kept constant. The miniature fuel blocks were prepared as described in Section A and had 1.53 grams of starter mixture in the center of the top surface of the fuel mixture. The surveillance period was 4 weeks of arctic (-65°F) storage including 1 day of ambient storage after the second week. The fuel blocks were sealed with only a thin layer of collodion, which tended to peel and crack during storage. The results shown in table 1 do not establish any significant relationship between the amount of swelling and consolidation pressure.

TABLE 1

EFFECT OF CONSOLIDATION PRESSURE ON TENDENCY OF AMMONIUM NITRATE FUEL BLOCKS TO SWELL DURING STORAGE

(Three Blocks in Each Group)

Block group	Original average thickness of blocks	Dwell time	Water added	Consolidation pressure	Average amount of swelling: After 2 weeks of arctic storage	Average amount of swelling: After 4 weeks of arctic storage*
	in.	sec	%	psi	in.	in.
1	1.349	1	0	2000	0.0781	0.109
2	1.292	1	0	3000	0.0364	0.073
3	1.333	10	0	2000	0.0364	0.057
4	1.318	10	0	3000	0.0156	0.046
5	1.266	1	5	2000	0.0312	0.109
6	1.276	1	5	3000	0.0313	0.063
7	1.214	10	5	2000	0.0261	0.062
8	1.156	10	5	3000	0.0839	0.130
9	1.396	1	1	2000	0.0625	0.172
10	1.281	10	1	2000	0.109	0.307
11	1.276	1	1	3000	0.104	0.286
12	1.224	10	1	3000	0.0839	0.266
13	1.281	1	3	2000	0.0677	0.114
14	1.307	1	3	3000	0.0417	0.078
15	1.260	10	3	2000	[illegible]364	0.135
16	1.365	10	3	3000	[illegible]0313	0.114

* After 2 weeks, the blocks were kept at ambi[illegible]emperature for 1 day.

A different batch of ammonium nitrate was used to obtain the results shown in table 2. The fuel blocks were consolidated as before, but no starter mixture was added. The controllable variables were kept the same for all blocks, but consolidation pressure varied. The surveillance period included 4 weeks of arctic (-65°F), 1 day of ambient-temperature, and 4 weeks of desert (160°F) storage. The M6 bodies containing the miniature fuel blocks were stored in taped fiberboard packing containers. The data in this table do not conclusively indicate any significant relationship between the consolidation pressures used and the amount of swelling.

TABLE 2

EFFECT OF CONSOLIDATION PRESSURE ON TENDENCY OF AMMONIUM NITRATE FUEL BLOCKS TO SWELL DURING STORAGE

Blocks groups	Blocks in each group	Original average thickness of blocks	Dwell time	Water added	Consolidation pressure	Average amount of swelling: After 4 weeks of arctic storage	Average amount of swelling: After 4 weeks of arctic, 1 day of ambient, and 4 weeks of desert storage
		in.	sec	%	psi	in.	
17	6	1.181	1	0	3000	0.0495	0.146
18	9	1.225	1	0	2500	0.0451	0.151

The data in table 3 are for fuel mixtures pressed at different consolidation pressures. The fuel blocks were consolidated in two increments of 107 grams of "slow" mixture and 25.4 grams of "fast" mixture and then stored in taped M6 fiberboard packing containers. The surveillance period was 4 weeks of storage under desert (160°F) conditions. The results, as shown in table 3, indicate that no significant relationship exists between consolidation pressure and the amount of swelling.

2. Dwell Time

The data in table 1 may be rearranged to show the effects of dwell time on the tendency of the miniature fuel blocks to swell during storage under arctic conditions (see table 4). A significant relationship cannot, however, be drawn between dwell time and amount of swelling from these inconsistent data.

TABLE 3

EFFECT OF CONSOLIDATION PRESSURE ON TENDENCY OF AMMONIUM NITRATE FUEL BLOCKS TO SWELL DURING STORAGE

Block group	Blocks in each group	Original average thickness of blocks	Dwell time	Water added	Consolidation pressure	Average amount of swelling after 4 weeks of desert storage
		in.	sec	%	psi	in.
19	9	1.293	1	0	2000	0.109
20	9	1.207	1	0	3500	0.111

A different batch of ammonium nitrate was used in obtaining the results shown in table 5. The fuel blocks were consolidated in two increments of 107 grams of "slow" mixture and 25.4 grams of "fast" mixture. No starter mixture was used, and the controllable variables, with the exception of dwell time, were kept the same for all blocks. The surveillance period included 4 weeks arctic (-65°F), 1 day ambient-temperature, and 4 weeks of desert (160°F) storage. The M6 bodies containing the miniature fuel blocks were stored in taped fiberboard packing containers.

Table 5 shows that blocks with a dwell time of 5 seconds swelled slightly more after storage under arctic conditions and slightly more after storage under both arctic and desert conditions than did blocks with a 10-second dwell time.

The data in table 6 are for fuel mixtures pressed at different dwell times, but with all other controllable variables kept the same. The fuel blocks were consolidated in two increments of 107 grams of "slow" mixture and 25.4 grams of "fast" mixture. The M6 bodies containing the miniature fuel blocks were stored in taped fiberboard packing containers. The surveillance period was 4 weeks of storage under desert (160°F) conditions.

3. Moisture Content.

The data in tables 7 and 8 are fuel mixtures having different moisture content; all other controllable variables were kept the same.

TABLE 4

EFFECT OF DWELL TIME ON TENDENCY OF AMMONIUM NITRATE FUEL BLOCKS TO SWELL DURING STORAGE

Block group	Original average thickness of blocks	Consolidation pressure	Water added	Dwell time	Average amount of swelling: After 2 weeks of arctic storage	Average amount of swelling: After 4 weeks of arctic storage *
	in.	psi	%	sec	in.	
1	1.348	2000	0	1	0.0781	0.109
3	1.329	2000	0	10	0.0363	0.057
2	1.291	3000	0	1	0.0363	0.073
4	1.317	3000	0	10	0.0156	0.047
5	1.265	2000	5	1	0.0312	0.109
7	1.213	2000	5	10	0.0261	0.062
6	1.275	3000	5	1	0.0312	0.063
8	1.156	3000	5	10	0.0833	0.130
9	1.395	2000	1	1	0.0625	0.172
10	1.281	2000	1	10	0.1093	0.307
11	1.275	3000	1	1	0.1042	0.286
12	1.223	3000	1	10	0.0833	0.266
13	1.296	2000	3	1	0.0676	0.114
15	1.260	2000	3	10	0.0364	0.135
14	1.307	3000	3	1	0.0417	0.078
16	1.364	3000	3	10	0.0469	0.114

* After 2 weeks, the blocks were kept at ambient temperature for 1 day.

TABLE 5

EFFECT OF DWELL TIME ON TENDENCY OF AMMONIUM NITRATE FUEL BLOCKS TO SWELL DURING STORAGE

Block group	Blocks in each group	Original average thickness of blocks	Water added	Consolidation pressure	Dwell time	Average amount of swelling: After 4 weeks of arctic storage	Average amount of swelling: After 4 weeks of arctic, 1 day of ambient, and 4 weeks of desert storage
		in.	%	psi	sec	in.	
21	9	1.267	0	2000	5	0.0625	0.214
22	9	1.196	0	2000	10	0.0520	0.160

TABLE 6

EFFECT OF DWELL TIME ON TENDENCY OF AMMONIUM NITRATE FUEL BLOCKS TO SWELL DURING STORAGE

Block group	Blocks in each group	Original average thickness of blocks	Water added	Consolidation pressure	Dwell time	Average amount of swelling after 4 weeks of desert storage
		in.	%	psi	sec	in.
19	9	1.293	0	2000	1	0.109
23	9	1.215	0	2000	30	0.113

The fuel blocks were consolidated in two increments of 107 grams of "slow" mixture and 25.4 grams of "fast" mixture, and the blocks in fuel-block groups 24 and 25 contained approximately 1.5 grams of starter mixture. Blocks in fuel-block groups 26 and 27 had a surveillance period of 4 weeks of arctic (-65°F), 1 day of ambient-temperature, and 4 weeks of desert (160°F) storage. The M6 bodies containing the miniature fuel blocks were stored in taped fiberboard packing containers. These tables show that blocks with no water

added to them swelled slightly more than blocks with 2% water added, and the data indicate that increased moisture content would cause a slight decrease in swelling.

TABLE 7

EFFECT OF MOISTURE CONTENT ON THE TENDENCY OF AMMONIUM NITRATE FUEL BLOCKS TO SWELL DURING STORAGE

Blocks groups	Blocks in each group	Original average thickness of blocks	Dwell time	Consolidation pressure	Water added	Average amount of swelling: After 4 weeks of arctic storage	Average amount of swelling: After 4 weeks of arctic, 1 day of ambient, and 4 weeks of desert storage
		in.	sec	psi	%	in.	
24	9	1.354	1	2000	0	0.0729	0.187
25	9	1.236	1	2000	2	0.0503	0.137

TABLE 8

EFFECT OF MOISTURE CONTENT ON THE TENDENCY OF AMMONIUM NITRATE FUEL BLOCKS TO SWELL DURING STORAGE

Block group	Blocks in each group	Original average thickness of blocks	Dwell time	Consolidation pressure	Water added	Average amount of swelling after 4 weeks of desert storage
		in.	sec	psi	%	in.
26	9	1.265	1	2000	0	0.127
27	9	1.211	1	2000	2	0.114

4. Starter Mixture.

The data in table 9 are for six fuel blocks consolidated without starter mixture and three fuel blocks consolidated with approximately 1.5 grams of starter mixture in the center of the top increment; all other controllable variables were kept the same. The fuel blocks were consolidated in two increments of 107 grams of "slow" mixture and 25.4 grams of "fast" mixture. The M6 bodies containing the miniature fuel blocks were stored in taped fiberboard packing containers. The surveillance period included 4 weeks of arctic (-65°F), 1 day of ambient-temperature, and 4 weeks of desert (160°F) storage.

Table 9 shows that blocks having 1.5 grams of starter mixture, 3/4 inch in diameter, in the center of the top increment swelled more after storage under arctic and desert conditions than blocks having no starter mixture. The starter mixture apparently contributes slightly to the swelling of the fuel blocks. (It was observed that the starter mixture tended to swell independently of the fuel mixture matrix.)

5. "Fast" and "Slow" Mixtures and Pure Ammonium Nitrate.

The data in table 10 were obtained from tests conducted do determine whether "fast" and "slow" mixtures and pure ammonium nitrate swell similarly. Block groups 29 and 32, 30 and 33, and 31 and 34 contained 100 grams of "slow" mixture, 100 grams of "fast" mixture, and 100 grams of pure ammonium nitrate, respectively. The blocks in block group 29, 30, and 31 were pressed in two increments of 75 grams and 25 grams each, and those in block groups 32, 33, and 34 in one increment. The M6 bodies containing the miniature fuel blocks were stored in fiberboard packing containers. The surveillance period included 4 weeks of arctic (-65°F), 1 day of ambient-temperature, and 4 weeks of desert (160°F) storage.

Table 10 shows that fuel blocks in all groups composed of "fast" mixture swelled slightly more after storage under arctic and desert conditions than blocks composed of "slow" mixture, and that these blocks swelled much more than blocks composed of pure ammonium nitrate. The blocks of pure ammonium nitrate caked hard and were flat after storage, but the blocks of "fast" and "slow" mixtures exhibited the typical domes (unconsolidated upper surface) characteristic of the other swollen miniature fuel blocks tested. This could be explained by considering the physical nature of the fuel mixtures as compared to pure ammonium nitrate. The fuel mixtures, as pointed out in section A of this report, are composed of individual grains of ammonium nitrate separated by paraffin and charcoal particles, but pure ammonium nitrate has nothing in it to keep the individual

TABLE 9

EFFECT OF STARTER MIXTURE ON THE TENDENCY OF AMMONIUM NITRATE FUEL BLOCKS TO SWELL DURING STORAGE

Block group	Blocks in each group	Original average thickness of blocks	Water added	Conso-lidation pressure	Dwell time	Starter mixture	Average amount of swelling	
							After 4 weeks of arctic storage	After 4 weeks of arctic, 1 day of ambient, and 4 weeks of desert storage
		in.	%	psi	sec		in.	
17	6	1.182	0	3000	1	No	0.0495	0.146
28	3	1.182	0	3000	1	Yes	0.0573	0.234

TABLE 10

RESULTS OF TESTS CONDUCTED TO DETERMINE WHETHER "FAST" AND "SLOW" MIXTURES AND PURE AMMONIUM NITRATE SWELL SIMILARLY

Block group	Blocks in each group	Original average thickness of blocks	Water added	Dwell time	Consolidation pressure	Starter mixture	Average amount of swelling: After 4 weeks of arctic storage	Average amount of swelling: After 4 weeks of arctic, 1 day of ambient, and 4 weeks of desert storage
		in.	%	sec	psi		in.	in.
Blocks consolidated in two increments								
29	3	0.989	0	1	2000	"Slow"	0.0364	0.125
30	3	1.010	0	1	2000	"Fast"	0.0469	0.141
31	3	1.922	0	1	2000	Ammonium nitrate	0.0261	0.063
Blocks consolidated in one increment								
32	4	1.015	0	1	2000	"Slow"	0.0625	0.121
33	4	1.054	0	1	2000	"Fast"	0.0586	0.152
34	4	0.984	0	1	2000	Ammonium nitrate	0.0351	0.0273

particles distinct. Pure ammonium nitrate, when swelling uniformly, acted somewhat as though there had been a considerable fusion of the individual grains, so that no bridging or doming action could develop to any extent between separate swelling grains. The fuel mixtures showing the typical domed type of swelling probably retained the structure of separate individual crystals of ammonium nitrate.

6. Consolidation in One and Two Increments.

The data in table 11 are for fuel blocks pressed in one or two increments. All blocks contained 107 grams of "slow" mixture and 25.4 grams of "fast" mixture, and the M6 bodies containing the miniature fuel blocks were stored in taped fiberboard packing containers. The surveillance period was 4 weeks of storage under desert (160°F) conditions.

TABLE 11

A COMPARISON OF THE AMOUNT OF SWELLING OF BLOCKS PRESSED IN ONE INCREMENT WITH THAT OF BLOCKS PRESSED IN TWO INCREMENTS

Block group	Blocks in each group	Original average thickness of blocks	Conso-lidation pressure	Water added	Dwell time	Number of increments	Average amount of swelling after 4 weeks of storage in desert
		in.	psi	%	sec		in.
26	9	1.265	2000	0	1	2	0.127
35	9	1.347	2000	0	1	1	0.064

The results in table 11 show that the blocks consolidated in two increments swelled much more after 4 weeks of storage under desert conditions than blocks consolidated in one increment. After storage, however, the average over-all thickness of the fuel blocks in block group 35 was slightly greater than that of the ones in block group 26. The smaller amount of swelling in the blocks consolidated in one increment was more than offset by their greater original thickness.

7. Cellulose-Nitrate Disk Seal.

The data in table 12 are for tests conducted to determine whether blocks sealed with a cellulose-nitrate disk would swell differently from unsealed blocks. All blocks were composed of 107 grams of "slow" mixture and 25.4 grams of "fast" mixture pressed in one increment. Both the sealed and unsealed M6 bodies containing the miniature fuel blocks were stored in taped fiberboard packing containers. The surveillance period was 4 weeks of storage under desert (160°F) conditions.

TABLE 12

RESULTS OF TESTS CONDUCTED TO DETERMINE WHETHER BLOCKS SEALED WITH A CELLULOSE-NITRATE DISK SWELL DIFFERENTLY FROM UNSEALED BLOCKS

Block group	Blocks in each group	Original average thickness of block	Consoli-dation pressure	Water added	Dwell time	Cellulose-nitrate disk seal	Average amount of swelling after 4 weeks of desert storage
		in.	psi	%	sec		in.
36	5	1.325	2500	0	1	No	0.0875
37	4	1.359	2500	0	1	Yes	0.0976

Table 12 shows that blocks with cellulose-nitrate disk seals swelled only slightly more than blocks having no seals. There appears to be no significant relationship between the use of a cellulose-nitrate disk seal and the tendency of fuel blocks to swell.

8. Concave Upper Surface.

Blocks with concave and flat upper surfaces showed the characteristic doming noted in other swelled fuel blocks. Swelling was most severe in the center rather than along the circumference of the fuel block. Since the centers of the concave blocks were already depressed, the swelling merely tended to offset the depression.

9. <u>Swelling.</u>

In no cases were there blocks in which no signs of swelling appeared after 4 weeks or more of storage under arctic or desert conditions.

III. CONCLUSIONS.

No change in the physical variables inherent in the loading procedure of fuel blocks is capable of completely eliminating the tendency of ammonium nitrate fuel blocks to swell.

APPENDIXES

APPENDIX A

MILITARY STANDARD FORMULA FOR FUEL MIXTURE - I

Ingredient	Ammonium nitrate	Charcoal	Paraffin wax
Specification	JAN-A-175[1] (grade III)	JAN-C-178 (class d)	U. S. Army 2-63 (type III, grade B)
Particle size (U. S. Standard sieve sizes-Fed. Spec. RR-S-366)			
	Percentage passing (Reground to pass)		
No. 60 sieve	95 minimum	98 minimum	
No. 100 sieve	15 minimum		
No. 140 sieve		80 minimum	
No. 200 sieve	50 maximum		
No. 325 sieve		50 minimum, 80 maximum	
Parts by weight	86 ± 0.5	9.0 ± 0.5	4.5[2]

[1]Granulated ammonium nitrate shall be dried to constant weight at approximately 150°F. and then ground to the correct particle size. The moisture content prior to mixing shall not exceed 0.10 percent.

[2]The quantity of paraffin wax may be varied between a minimum of 3 parts and a maximum of 6 parts, by weight, to meet the specified functioning requirements.

The paraffin wax may be melted and spray granulated under pressure through a spray nozzle. A maximum of 0.1 percent of charcoal, by weight, may be added to the granular wax to prevent agglomeration.

Extreme care should be exercised during the grinding and mixing of ammonium nitrate in order to prevent fires and explosions.

All sieve tests of ammonium nitrate or charcoal shall be made by shaking a 100-gm. sample of ammonium nitrate or a 20-gm. sample of charcoal in a single-eccentric type mechanical shaker which imparts to the sieves a rotary motion and tapping action of uniform speed of 300 ± 15 gyrations and 150 ± 10 taps of the striker per minute.

MILITARY STANDARD FORMULA FOR FUEL MIXTURE - II

Ingredient	Ammonium nitrate	Charcoal	Paraffin wax
Specification	JAN-A-175[1] (grade III)	JAN-C-178 (class d)	U. S. Army 2-63 (type III, grade B)
Particle size (U. S. Standard sieve sizes - Fed. Spec. RR-S-366)			
	Percentage passing (Reground to pass)		
No. 60 sieve	95 minimum	98 minimum	
No. 100 sieve	15 minimum		
No. 140 sieve	8	80 minimum	
No. 200 sieve	50 maximum		
No. 325 sieve		50 minimum, 80 maximum	
Parts by weight	88.7 ± 0.5	10.3 ± 0.5	1.0.[2]

[1]Granulated ammonium nitrate shall be dried to constant weight at approximately 105°F. and then ground to the correct particle size. The moisture content prior to mixing shall not exceed 0.10 percent.

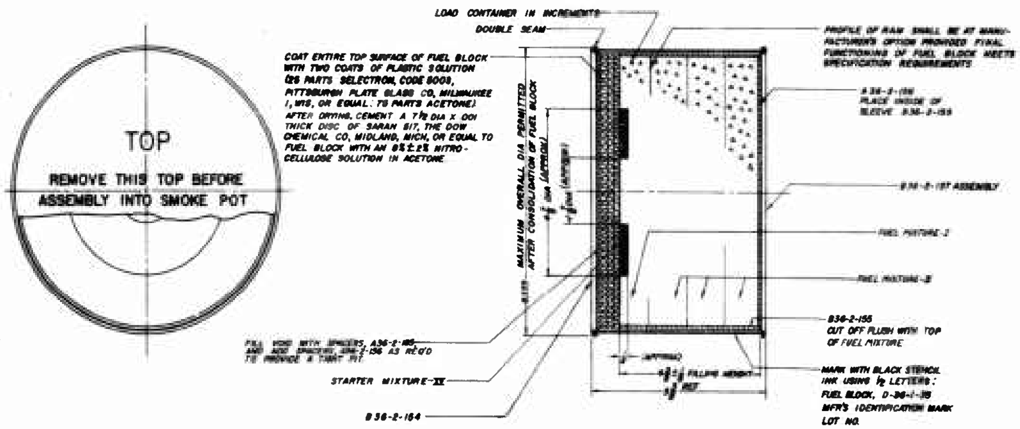
[2]The quantity of paraffin wax may be varied between a minimum of 0.75 parts and a maximum of 1.75 parts, by weight, to meet the specified functioning requirements.

The paraffin wax may be melted and spray granulated under pressure through a spray nozzle. A maximum of 0.1 percent of charcoal, by weight, may be added to the granular wax to prevent agglomeration.

The maximum of 1 quart of acetone to 100 pounds of mix may be added to the ingredients in the mixer to increase the apparent density. The mix shall then be dried until the order of acetone is no longer apparent.

Extreme care should be exercised during the grinding and mixing of ammonium nitrate in order to prevent fires and explosions.

All sieve tests of ammonium nitrate or charcoal shall be made by shaking a 100-gm. sample of ammonium nitrate or a 20-gm. sample of charcoal in a single-eccentric type mechanical shaker which imparts to the sieve a rotary motion and tapping action of uniform speed of 300 ± 15 gyrations and 150 ± 10 taps of the striker per minute.



(b) NUMBER AS REQUIRED

1 LINE	2 DRAWING NUMBER	3 DRAWING DATE	4 NO. REQ'D	5 NOMENCLATURE	6 MATERIAL	7 SPECIFICATION NUMBER	8 SPECIFICATION DATE
1	D36-1-33		–	BLOCK, FUEL, ASSEMBLY AND DETAIL			
2							
3			–	INK STENCIL, BLACK		TT-I-558	
4			–	NITROCELLULOSE-GRADE D-EXCEPT WITH NITROGEN CONTENT OF 11.3TO11.7%		JAN-N-244	
5			–	SELECTRON, CODE 5003, PITTSBURG PLATE GLASS CO, MILWAUKEE 1, WIS, OR EQUAL		—	
6			–	ACETONE		O-A-51	
7			–	STARTER MIXTURE-XX (GRANULATED)	MS 546	—	
8			–	FUEL MIXTURE-I	MIL-STD-545	–	
9			–	FUEL MIXTURE-II	MIL-STD-546	–	
10			1	DISC 7 1/2 DIA X .001 THICK, SARAN 517, THE DOW CHEMICAL CO,			
11					MIDLAND, MICH. OR EQUAL	—	
12							
13	B36-2-137		1	CONTAINER, FUEL BLOCK, ASSEMBLY AND DETAIL		—	
14			–	MATERIALS FOR LINE 13	COLD-ROLLED CARBON STEEL SHEET,		
15					CONDITION NO.4, COATED BOTH SIDES CLEAR		
16					LACQUER, OR PHENOLIC COATING OR,	MIL-S-10104	
17			–		107 LB BASE WEIGHT COMMERCIAL SPECIAL-		
18					COATED MANUFACTURING TERNE PLATE,		
19					PRIMES ONLY, COATED BOTH SIDES CLEAR		
20					LACQUER, OR PHENOLIC COATING	MIL-S-10104	
21			–	SOLDER, SOFT	COMPOSITION Sn 30	QQ-S-571	
22							
23	B36-2-164		1	TOP	COLD-ROLLED CARBON STEEL SHEET,		
24					CONDITION NO.4, COATED BOTH SIDES		
25					CLEAR LACQUER OR PHENOLIC		
26					COATING OR,	MIL-S-10104	
27					107 LB BASE WEIGHT COMMERCIAL		
28					SPECIAL-COATED MANUFACTURING		
29					TERNE PLATE, PRIMES ONLY, COATED		
30					BOTH SIDES CLEAR LACQUER OR		
31					PHENOLIC COATING	MIL-S-10104	
32			–	LINING COMPOUND		—	
33							
34	A36-2-156		(b)	SPACER	PLAIN CHIPBOARD	—	
35							
36	B36-2-155		1	SLEEVE	SPIRALLY WOUND CHIPBOARD TUBE,		
37					OR PLAIN CHIPBOARD	—	
38			–	GLUE	GRADE II	MIL-G-20469	
39				RUBBER CEMENT	TYPE I	ZZ-C-181	
40	A36-2-185		(b)	SPACERS	DOUBLE FACED CORRUGATED		
41					FIBERBOARD, FLUTE A	#197-54-619	
42							
43							
44							

NOTE:
REMOVE TOP BY SUITABLE MEANS AND REMOVE ALL SPACERS ON TOP OF BURNING MIXTURE PRIOR TO ASSEMBLY WITH SMOKE POT.

PURCHASE DESCRIPTION

TOLERANCES ON DECIMALS — FRACTIONS ± 1/16 ANGLES —

APPLICATION: D36-1-32, D36-1-111, C36-1-46, D36-1-108

9 SEPT 1947 — H.C. — C.L.B. — J.F.B. — G.A.B. — J.J.W. — M.M.

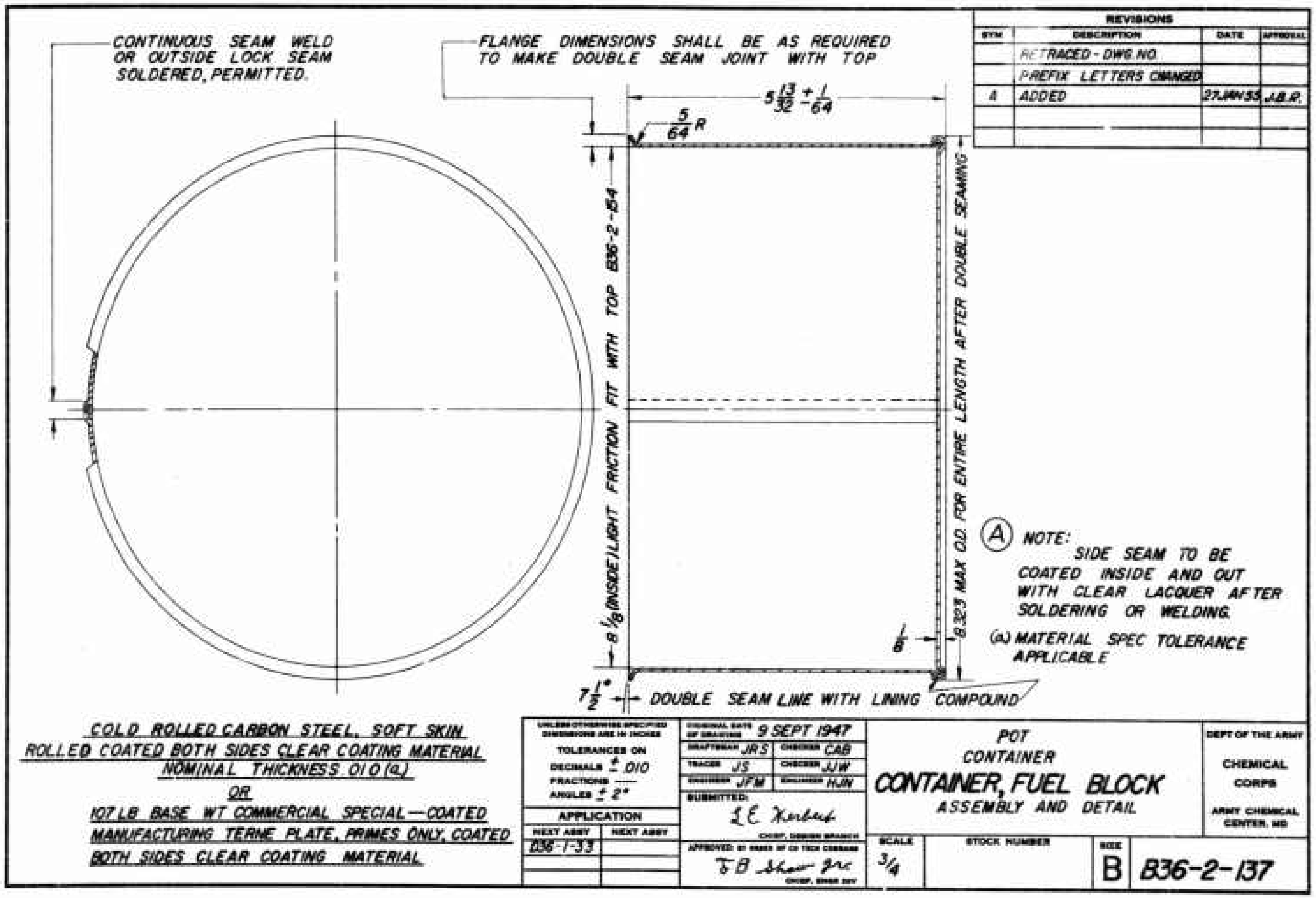
L.B. Hubert

J.B.D.

POT
SMOKE
BLOCK, FUEL
ASSEMBLY, DETAIL AND BILL OF MATERIAL

SCALE 1/4

D 036-1-33


CONTINUOUS SEAM WELD OR OUTSIDE LOCK SEAM SOLDERED, PERMITTED.
FLANGE DIMENSIONS SHALL BE AS REQUIRED TO MAKE DOUBLE SEAM JOINT WITH TOP
5 13/32 +1/-64
5/64 R
8 1/8 (INSIDE) LIGHT FRICTION FIT WITH TOP B36-2-154
8.323 MAX O.D. FOR ENTIRE LENGTH AFTER DOUBLE SEAMING
1/8
7 1/2°
DOUBLE SEAM LINE WITH LINING COMPOUND
REVISIONS
SYM
DESCRIPTION
DATE
APPROVAL
RETRACED - DWG NO.
PREFIX LETTERS CHANGED
A
ADDED
27JAN55
J.B.P.
(A) NOTE: SIDE SEAM TO BE COATED INSIDE AND OUT WITH CLEAR LACQUER AFTER SOLDERING OR WELDING.
(a) MATERIAL SPEC TOLERANCE APPLICABLE
COLD ROLLED CARBON STEEL, SOFT SKIN ROLLED COATED BOTH SIDES CLEAR COATING MATERIAL NOMINAL THICKNESS .010 (a)
OR
107 LB BASE WT COMMERCIAL SPECIAL—COATED MANUFACTURING TERNE PLATE, PRIMES ONLY, COATED BOTH SIDES CLEAR COATING MATERIAL
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
FRACTIONS —
ANGLES ± 2°
APPLICATION
NEXT ASSY
NEXT ASSY
B36-1-33
ORIGINAL DATE OF DRAWING 9 SEPT 1947
DRAFTSMAN JRS
CHECKER CAB
TRACER JS
CHECKER JJW
ENGINEER JFM
ENGINEER HJN
SUBMITTED:
CHIEF, DESIGN BRANCH
APPROVED: BY ORDER OF CO TECH COMMAND
T B Shaw Jr.
CHIEF, ENGR DIV
POT
CONTAINER
CONTAINER, FUEL BLOCK
ASSEMBLY AND DETAIL
DEPT OF THE ARMY
CHEMICAL CORPS
ARMY CHEMICAL CENTER, MD
SCALE
3/4
STOCK NUMBER
SIZE
B
B36-2-137

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